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surface of the glass. The silvered mirror used was not perfect, and a perfect silver surface would undoubtedly reflect more, — probably as much as 91 or 92 per cent. Since relative results were desired, but one reflecting angle was used in the above experiments.

No. XX. — EFFECT OF DISTANCE ON APPRECIATION OF COLOR.

By W. H. Schwartz.

Presented Dec. 10, 1879.

Herbert Spencer, in his *First Principles of Philosophy*, adduces the following as an instance of heterogeneity in the formation of the Universe: —

"While the yellow stars are found in all parts of the heavens, the red and blue stars are not so; there are wide regions in which both red and blue stars are rare; there are regions in which the red are comparatively abundant."

Professor Trowbridge suggested to me that the relative distance of the stars, and their relative size, might affect our perception of color, and that a colored star might appear of a faint white or yellow tint on a dark background, if it were distant, compared with a colored star which was at a less distance: in other words, that Herbert Spencer's instance could not be adduced as an evidence of heterogeneity.

I therefore undertook the following investigation.

The solar spectrum having been projected upon a white wall, I covered it by a white screen provided with vertical slits at various distances, and in this way compared my appreciation of the color seen through these slits at various distances. I speedily found that the following experiments with slips of colored paper represented the results which I obtained with the normal colors of the spectrum, and brought out the facts equally well. I therefore abandoned the spectrum, and confined myself to the colored papers.

Red, Green, and Yellow.

I first tried strips of red, green, and yellow on a *white background.* The strips were about .0015 meter wide and .025 meter long. They were parallel and about .01 meter apart.

At first, I took red and green strips. At a distance of 12 meters I could tell the difference between the strips because the red was darker than the green, but I could not distinguish the colors at that distance. I could distinguish the colors at about 9 meters. I could tell the direction of the strips at about 16 meters.

I next took green and yellow strips. I could perceive that there was a difference between the colors at 10.5 meters, because the yellow almost blended with the white background, while the green did not look so faint. I could make out the green color at 8 meters, the yellow at 7.5 meters. The direction of the strips could be seen at 14 meters; but no difference could be detected in the colors.

With red and yellow I could perceive that there was a difference at 12 meters, since the red appeared darkest on the white background. I could make out the red color at 9 meters, the yellow at 7.5, and tell the direction of the strips at 16 meters.

All the above were on a *white* background. I then took a *black* background.

Yellow and Green (*narrow strips*).

Could distinguish the colors at 13 meters. Could tell the direction of the strips at 20 meters.

Red and Yellow (*narrow*).

The yellow is visible at 20 meters, but cannot make out the color at that distance. I can make out the color at 13 meters. Red color is just visible at 8 meters. I can see that there is a strip where the red is, but cannot make out the color at 10 meters.

Red and Green (*narrow strips*).

The green can be seen in contrast to the black at 20 meters. The green color can be detected at 13.5 meters. I can make out the red color at 8 meters. The red blends with the black background at 10 meters.

Yellow and Green (*strips twice as wide as those used above*).

I could distinguish a difference of tint at 20 meters; but could make out the colors at 18 meters.

Red and Yellow (*double width*).

The red color can be made out at 13 meters; but the red strip becomes invisible at 15 meters.

The following measurements were made out of doors: —

Narrow green: color was visible at	35 yards.
Narrow yellow: color was visible at	24 “
Narrow red: color was visible at	16 “

Double Width.

Green color visible at	56 yards.
Red “ “	28 “
Yellow “ “	40 “

Red became invisible at 31 yards. I could see the light-colored strips at 75 yards

Triple Width.

Green color visible at	72 yards.
Red “ “	40 “
Yellow “ “	60 “

The following strips were very carefully measured and cut: —

Narrow Strips.

Yellow color visible at	29 paces.
Green “ “	34 “
Red “ “	18 “

I could see that there were light-colored strips at 48 paces, but could not detect any difference in the colors. The red became invisible at 21 paces.

Double Width.

Yellow color invisible at	43 paces.
Green “ “	51 “
Red “ “	23 “

Triple Width.

Yellow visible at	56 paces.
Green “	67 “
Red “	34 “

By putting these results in close connection, we can compare them to better advantage: —

	Narrow.	Double.	Triple.
Red	16 yards	28 yards	40 yards.
Yellow	24 "	34 "	60 "
Green	35 "	56 "	72 "

These strips were not measured very accurately, but the following were carefully measured: —

	Narrow.	Double.	Triple.
Red	18 paces	23 paces	34 paces.
Yellow	29 "	43 "	56 "
Green	34 "	51 "	67 "

We see from the above table that when the strips are three times as wide, the distance at which they can be seen is just about double.

My conclusions therefore are as follows: —

1. Herbert Spencer's instance cannot be accepted as an evidence of heterogeneity.
2. Distance is an important element in our perception of color. Every one may be said to be color-blind in reference to the stars.
3. The three factors, distance, intensity, and amount of surface from which the illumination proceeds, should be considered in the location of colored signal-lights.
4. Spectrum analysis of very faint stars does not aid us in determining their color, on account of the faintness of the lines.

No. XXI. — SIMPLE APPARATUS FOR ILLUSTRATING PERIODIC MOTION.

By John Trowbridge.

Presented Dec. 10, 1879.

There are many ways of showing Lissajous' experiments, and on many accounts the tuning-fork method is the best; but the apparatus is expensive and cannot be readily obtained. The following forms of apparatus can be made by any one at a trifling expense.

No. 1. — *Graphical Method.*

The apparatus represented in Fig. 1 draws the curves before an audience on the screen, and does not require a vertical lantern. A is